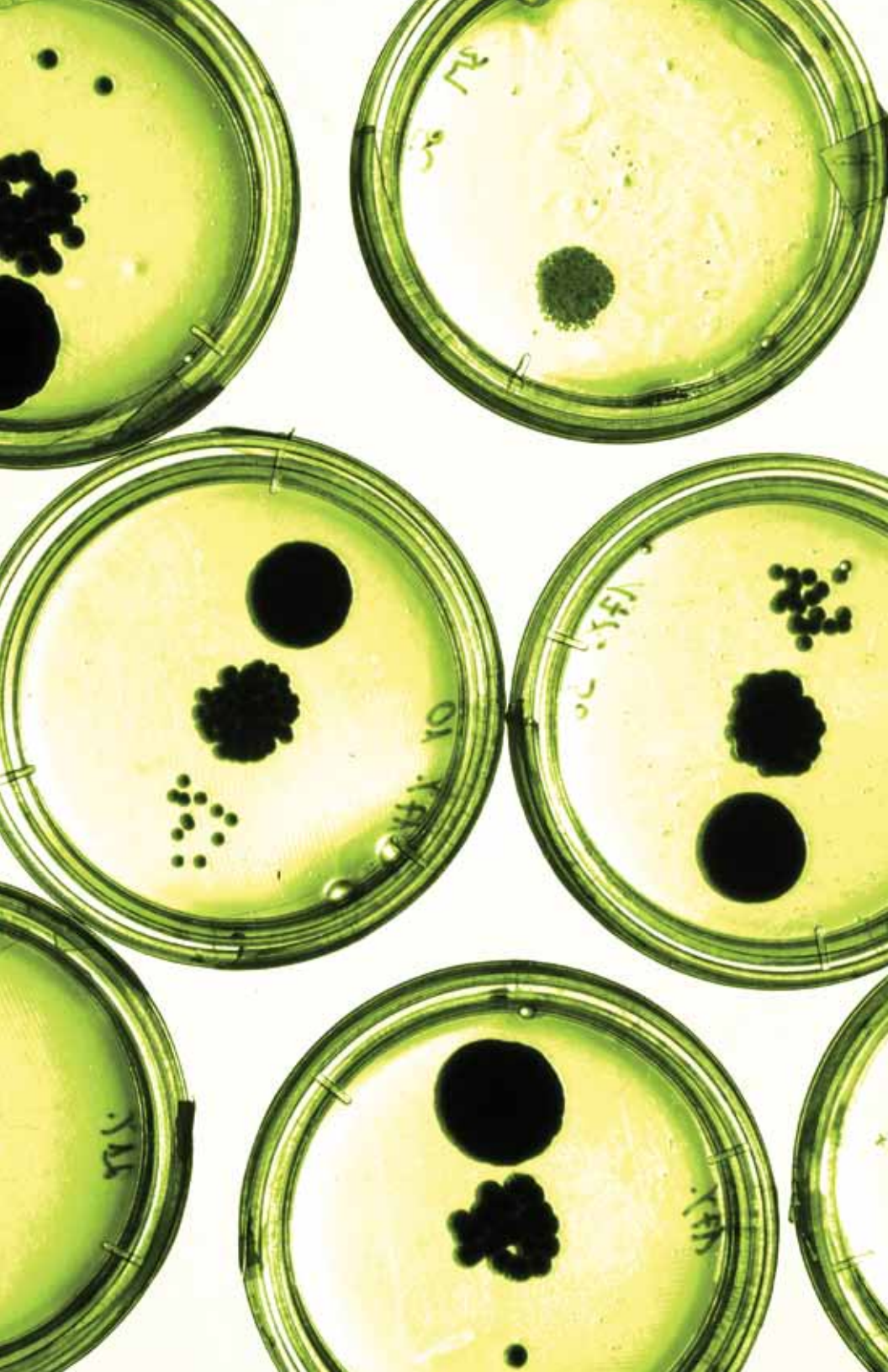
SIMB Society for Industrial Microbiology and Biotechnology

Careers In
Industrial Microbiology & Biotechnology

Looking for an Exciting Career?

A career in industrial microbiology and biotechnology may be just the one for you. The following information answers questions most people have about this exciting and challenging career path:

- What is industrial microbiology and biotechnology?
- What kind of work does an industrial microbiologist do?
- What training and education are required to succeed in industrial microbiology and biotechnology?
- Why should someone consider a career in industrial microbiology and biotechnology?



What is Industrial Microbiology/Biotechnology?

Industrial microbiology or microbial biotechnology is the application of scientific and engineering principles to the processing of materials by microorganisms (such as bacteria, fungi, algae, protozoa and viruses) or plant and animal cells to create useful products or processes. The microorganisms utilized may be native isolates, laboratory-selected mutants or microbes that have been genetically modified using recombinant DNA methods. Metagenomics, the study of all of the genetic material in an environmental sample, is being used to screen for microbes with potentially useful industrial properties. In some cases the organisms have been developed using synthetic biology, the design of new biological systems or the re-design of existing systems.. The terms "industrial microbiology" and "biotechnology" are often considered to be one and the same.

Areas of industrial microbiology include discovery of new organisms and pathways, such as antimicrobial drugs. For instance, most antibiotics come from microbial fermentations involving a group of organisms called actinomycetes. Other organisms such as yeasts are used in baking, in the production of alcoholic beverages, and in biofuel production. Additional groups of microorganisms form products that range from organic acids to enzymes used to create various sugars, amino acids, detergents, and consumer products/specialty ingredients. For example, the sweetener aspartame is derived from microbially produced amino acids. Industrial microbiologists may also be responsible for the bioremediation of air, soil, and water contamination.

Industrial microbiologists may also deal with products associated with the food, dairy, and consumer products industries, along with the prevention or deterioration of processed or manufactured goods, and with waste disposal systems. Quality assurance for the food, pharmaceutical, and chemical industries is a large area, along with the health of animals used in testing products.

For more in-depth coverage of topics in industrial microbiology, take a look at the Society for Industrial Microbiology and Biotechnology's peer-reviewed Journal of Industrial Microbiology and Biotechnology and its homepage, *http://www.springer.com/life+sciences/microbiology/journal/10295?*.

What Kind of Work Does an Industrial Microbiologist Do?

When choosing a career in industrial microbiology or biotechnology, you should be prepared to embrace a multidisciplinary science. Very rarely will challenges be limited to just one area, but rather will require investigation of several aspects of a process or production problem. In such circumstances, you will often need skills and expertise in additional fields such as molecular biology, biochemistry, immunology, and biostatistics. Collaborations are increasingly being made with disciplines such as chemical, environmental, and/or biomedical engineering. Synthetic biology is an excellent example of the need for a wide ranging background in many areas of science and engineering.

Many industrial microbiologists/biotechnologists are responsible for the discovery, development, or implementation of certain processes and the quality of resultant

ANTIBIOTICS/ANTIMICROBIALS

Both natural and chemically enhanced microbial products can be used to control human, animal, and plant diseases. Using traditional genetics or recombinant DNA techniques, the microorganisms can be modified to improve the yield or action of antibiotics and other antimicrobial agents. New research directions are aimed at discovering microbial metabolites (with pharmacological activities) useful in the treatment of hypertension, obesity, coronary heart disease, cancer, and inflammation.

VACCINES

Vaccines are essential to protect humans and animals from microbial diseases. Recombinant DNA technology has allowed for the production of vaccines that offer protection without risk of infection (e.g., hepatitis B vaccine). Industrial microbiologists are actively involved in the development of these new vaccines.

HEALTH-CARE PRODUCTS

The development and production of diagnostic assays that utilize monoclonal antibody or DNA probe technology are essential in the manufacture of health-care products such as rapid tests for strep throat, pregnancy, and AIDS. Microorganisms are also used to produce human or animal biologicals such as insulin, growth hormone, antibodies, and components for cosmetics. The industrial microbiologist/biotechnologist may screen new microbial sources (e.g., marine or cave-dwelling microorganisms) for their ability to produce new pharmaceuticals or develop new diagnostic assays.

FOOD/BEVERAGES PRODUCED BY MICROBIAL ACTIVITY

Yogurt, cheese, chocolate, butter, pickles, sauerkraut, soy sauce, food supplements (such as vitamins and amino acids), food thickeners (produced from microbial polysaccharides), alcohol (beer, whiskeys, and wines), sausages, and silage from animals are a small sample of products of microbial activity. Industrial microbiologists/biotechnologists may be involved in producing concentrated microbial inocula for fermentations or the maintenance of fermentation systems utilized in production facilities. They may also take part in identifying the organisms involved in and maintaining proprietary culture collections.

There is a great deal of microbiology in the food and beverage industries. Some examples are:

- Food/Beverages Cured or Improved by Microbial Activity: Production of coffee, tea, cocoa, summer sausage, vanilla, cheese, olives, and tobacco all require microbial activity and a microbiologist to insure product quality.
- Food Flavoring Agents and Preservatives: Organic acids, such as citric, malic, and ascorbic acids, and monosodium glutamate are microbial products commonly used in foods.
- Foods: Mushrooms, truffles, and some red and green algae are consumed directly. Yeasts are used in food supplements for humans and animals.

AGRICULTURE

Conventional, recombinant DNA and monoclonal antibody techniques are used to improve microbial inoculants which serve as fertilizer supplements by fixing atmospheric nitrogen to improve plant yields and to serve as plant pest controls. All of these require a microbiologist to insure product efficacy and quality.

ENZYMES

Industrial applications of enzymes include the production of cheese, the clarification of apple juice, the development of more efficient laundry detergents, pulp and paper production, and the treatment of sewage. These processes have been dramatically enhanced by the use of recombinant DNA techniques to design enzymes and increased activity, stability, and specificity.

CARBOHYDRATES

Some molecular sieves for purification/separation processes (e.g., dextran) and thickening agents (e.g., xanthan used in salad dressings), which are stable at high temperatures, are examples of microbial carbohydrates. The latter are also used for secondary oil recovery in oil fields and as lubricants in drilling oil wells, gelling agents in foods, and thickeners in both paints and foods.

ORGANIC CHEMICALS

Compounds such as acetone, methanol, butanol, and ethanol have multiple applications in industrial settings, often as raw materials for industrial processes. The microbiologist is involved in research on improvements in the production and detection of new metabolic pathways. Microbes will increasingly be used to supplant or replace those processes which rely on petroleum/natural gas for the production of these compounds.

CONTAMINATION CONTROL

The industrial microbiologist develops assays to detect microbial contaminants in food and develops preservatives; evaluates natural or synthetic agents for the prevention of disease, deterioration, or spoilage; and determines minute quantities of vitamins or amino acids in food samples. Microbiologists are also involved in the development of procedures for the control of deterioration in cosmetics, steel, rubber, textiles, paint, and petroleum products.

WASTE AND WASTEWATER MANAGEMENT

The production of clean water and the destruction of waste material are important for preserving the environment and providing drinkable water. The industrial microbiologist is directly involved in developing microbial strains to detoxify wastes of industrial, agricultural, or human origin.

OIL RECOVERY/MINING

Oil recovery may be facilitated by the development of unique bacteria which produce a surfactant that forces trapped oil out of the rocks. Extraction of minerals from low-grade ores is enhanced by some bacteria (microbial leaching). In addition, selective binding of metals by biohydrometallurgical processes is important in recycling of metals such as silver and uranium. Research and developments in these areas also offer career paths for industrial microbiologists/biotechnologists.

ENVIRONMENTAL MICROBIOLOGY

Examination of microbes living in unusual environments (e.g., high temperatures, salt, low pH or temperature, high radiation) may lead to discovery of or engineering of microbes with new abilities to degrade or transform pollutants and improve the environment. Industrial microbiologists/ biotechnologists are involved in engineering microbes to solve the contamination and recycling problems, and assess the environmental safety of new and exciting products.

What Training and Education Are Required to Succeed?

High school students interested in a career in industrial microbiology/biotechnology should take college preparatory courses in biology, mathematics, physics, and chemistry. You may become a skilled technician through on-the-job training, but many organizations require that a technician take career-related college level courses in order to advance to higher paying technical positions. Overall, employment opportunities in industrial microbiology/biotechnology are very limited for high school graduates.

Although many high school programs now offer formal microbiology/biotechnology instruction you will probably have to participate in extra-curricular activities (e.g., science fair projects or individualized study programs guided by your teacher or a scientist in the community) to supplement the material covered in these courses. Further exposure to industrial microbiology/biotechnology may be obtained by working during the summer in an industrial, university, or hospital microbiology laboratory; some of these positions may be in the form of internships. Your guidance counselor may also be helpful in identifying college, industry, and government-sponsored summer enrichment program for high school or undergraduate students.

Most professional levels of employment in Industrial Microbiology/Biotechnology require a college degree (BS) in biology, microbiology, biochemistry, molecular biology or biotechnology with minor/specializations in one or more of the complementary sciences such as those listed above and immunology, biostatistics, and/or some complimentary area in engineering or environmental science. Students able to work on one or more research projects while an undergraduate student may have advantages when being considered for employment (or graduate school). Such opportunities often are found within the college/university, but internships in industrial microbiology/biotechnology can also be found at various government and industrial labs. Information on these can typically be found through your advisor/career center and on-line at the various agencies/industries.

A person with a BS degree has several career options. One may begin a career in an industrial or clinical entry-level position. There may also be opportunities in sales of laboratory products or instruments. In many organizations, employees are encouraged to continue their educations. It may be possible in such an environment to obtain a higher degree while working full time. Many organizations employing industrial microbiologists/biotechnologists will have dual career paths for advancement. This means that the scientists will have the opportunity to advance to higher levels of responsibility either

by staying in their chosen technical field or by assuming administrative responsibilities in technical management. Advancement to Project Manager, Plant Manager, or Director is common. As with most careers, an individual advances based on his or her unique approach to assigned tasks and contributions to achievements of his or her employer.

Individuals with one or more advanced degrees (MS and/or PhD) in biology, microbiology, or some other allied field such as molecular biology, biochemistry, biotechnology, chemical engineering, physics or genetics can typically begin with higher project/program responsibilities when entering industrial-related positions. These positions may be in industry, government or academic situations. With the advanced degrees comes greater expectations for not only knowledge but increasing experiences with project design, conduct, and management. Multidisciplinary experiences are essential. In addition, attendance at national/international meetings is crucial for presenting research results and networking.

Well-developed communication skills are essential for any of these career paths, with the level of mastering of the skills directly related to the degree earned/position being sought. Experiences with both oral and written forms of scientific and technical communication are equally important. The ability to work well as part of group is important at all levels. Supervisory/project management experience becomes more important as the degree level increases. These experiences/skills can typically be obtained as part of the educational process, but students may at times need to seek out opportunities to work-on these skills.

For Additional Information

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Brochure (2014) on:
"Microbe-powered Jobs:
How microbiologists can help build the bioeconomy"
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Why Should Someone Consider a Career in Industrial Microbiology/Biotechnology?

A career in industrial microbiology/biotechnology offers a variety of work assignments. These may include basic research, process development, production, technical services, quality control, compliance control, or technical sales. Some individual microbiologists may be considered genetic engineers (utilizing recombinant DNA techniques) while others are classified as bioprocess engineers (optimizing enzymatic reaction systems for a desired product). If you are the kind of person who likes variety in work responsibilities and enjoys solving problems and making things work, you should seriously consider a career in this area.

As products developed by applied research move into production, a much wider range of personnel will be needed by industry, government, and academia. Industry will require scientists who can discover new products and develop methods for producing those products in large quantities. Government agencies will employ microbiologists/biotechnologists in research, regulatory, and oversight positions. Academia will require educators to prepare the next generation of industrial microbiologists/biotechnologists. Individuals who develop their skills and expertise will find mobility in the job marketplace since their basic background and training will be transferable to new opportunities.

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